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METHODS OF ALLOCATING WATER RESOURCES UNDER MACRO-DYNAMIC CONDITIONS

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled METHODS OF ALLOCATING WATER RESOURCES UNDER MACRO-DYNAMIC CONDITIONS submitted by JOSEPH LORNE HARTLEY in partial fulfilment of the requirements for the degree of Master of ARTS

ABSTRACT

The purpose of this thesis is to assess the usefulness of cost-benefit analysis in evaluating alternative programmes in the development of Canada's natural resources. The working hypothesis adopted in this study was that cost-benefit analysis is conceptually unable to deal with allocation problems in a macro-dynamic setting. Therefore, an attempt has been made to provide and assess alternative techniques for large-scale natural resource projects, including water resources.

After a thorough investigation of cost-benefit analysis, input-output models and agglomeration theory, it was concluded that dynamic input-output models combined with agglomeration theory are more conceptually correct in large-scale allocation programmes of Canada's natural resources. Since Canada is so richly endowed with natural resources and the future economic performance of Canada is, to a large extent, dependent on the efficient allocation of these resources, a thorough-going concern with the development of suitable analytical methods for natural resource allocations seems in order.

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CHAPTER I

INTRODUCTION

During the past decade Canada has been undertaking large scale development of the natural resources with which Canada has been so richly endowed. Therefore the method of analysis utilized in the allocation of these natural resources is extremely important to the national economy, and in some cases the methods used may be said to have been less than satisfactory. For example the Columbia River project utilized cost-benefit analysis for decision making purposes. For a project of this size, this method of analysis is believed to be entirely unsatisfactory for reasons which will be put forth in this thesis.

The major hypothesis of this thesis is that cost-benefit analysis is not a satisfactory tool of analysis for large scale natural resource projects. The arguments to support this thesis will be based upon the conceptual framework that is an integral part of cost-benefit analysis. The conceptual shortcomings of cost-benefit analysis prevents the analyst from predicting the effects of large scale projects on the economic growth of the area and, in general, economic growth of the entire economy.

Since Canada is, at the moment, considering or involved in large scale intra- and inter-regional transfers of natural resources, Canada should be concerned with methods used to allocate the natural resources. Since the thesis has indicated that cost-benefit analysis is not suitable for the allocation of Canada's natural resources, other methods of analysis will be examined.

Input-output analysis is then examined for its usefulness in allocating Canada's natural resources, primarily for its usefulness in large scale transfers of natural resources. But similar to cost-benefit analysis, input-output models are not free of drawbacks. The difficulties faced when input-output models are made dynamic will be examined and a conclusion as to whether dynamic input-output models are feasible or not will be attempted.

In natural resource projects in which a cost-benefit analysis has been used, major factors which affect the economic growth of the region and the economy in general have been deleted. Such factors as pecuniary externalities, and agglomeration effects of the project are deleted from a cost-benefit analysis but all influence economic growth. Because of agglomerative effects of projects and the effects on economic growth, agglomeration and the causes of agglomeration will be examined. Backward and forward linkages, urbanization economies, localization economies, and

economies of scale, all which are causes of agglomeration, very clearly affect the economic growth of a region and in general a large sector of the economy.

Thus, the point of this research topic is to provide a method of analysis of assessing the growth effects of the development of large-scale natural resource projects, which ~~indeed~~ is of considerable concern to Canada at the moment.

CHAPTER II

COST-BENEFIT ANALYSIS AND A CONCEPTUAL TREATMENT OF EXTERNALITIES AND SECONDARY BENEFITS

I. Introduction

Cost-benefit analysis has been extensively utilized by the United States Government for evaluating water resource projects. The direct and indirect benefits and costs of the project are computed to form the ratio of benefits to costs. Usually if the ratio is less than unity the project will not be accepted unless intangible and unmeasurable effects have an important bearing on the selection of the project. Such unmeasurable effects may include preservation or destruction of scenic beauty or wildlife, or the saving of human lives. If these unmeasurable effects cannot be evaluated, then benefit-cost ratios should be computed without them. Then this ratio should be compared with the ratio of the next best alternative and if it falls short the unmeasurable effects should be examined. "For the project to be selected, its intangible benefits must be shown to be large enough to make up for its deficit in measurable benefits."

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[1] W.R.D. Sewell, John Davis, A.D. Scott and D.W. Ross, Guide to Benefit-Cost Analysis (Ottawa, Queen's Printer, 1965), p. 19.

Where resources are limited, all desirable projects cannot be chosen. The government must make a choice. If the objectives of the project are economic, then economic criteria must be used in making the choice. Benefit-cost analysis is one form of economic criteria which may be used and is actually better for ranking alternatives than for accepting or rejecting projects. This is mainly caused by the fact that errors in calculating benefits and costs affect similar projects in similar ways, i.e. "the ratios will tend to be high or low in the same pattern, though differences in the composition of outputs and in the physical conditions of projects will still lead to errors even in ranking."[1]

But this method of choosing a project does not necessarily mean the project with the highest benefit-cost ratio will be chosen.[2] Return on investment as well as many restraints on costs must also be considered. If the costs

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[1]Otto Eckstein, "Benefit-Cost Analysis and Regional Development," in Regional Economic Planning, ed. W. Isard and J.H. Cumberland (Paris, O.E.E.C., 1960), p. 361.

[2]A benefit-cost ratio is only the ratio of total benefits to total cost and is not necessarily maximizing net benefits even though it may be the maximum cost-benefit ratio. The maximum cost-benefit ratio is not necessarily the point where marginal revenue is equal to marginal costs which is where net benefits are maximized. For example, if two similar hydro projects are considered; one with revenue of $100 and costs of $50 and the other with revenue of $900 and costs of $500, the first project would be chosen if we are maximizing the cost-benefit ratio but net benefits are not maximized, all other things remaining equal.

which may be incurred are limited, then projects must be chosen which have the largest amount of benefit per unit of costs. But this does not necessarily mean it has the highest return on investment. Therefore, return on investment as well as risks must be considered. Risk here can be viewed from two sides. First, the analyst must consider how much a project will reduce important risks, such as in flood control projects. Second, risks should be considered in the sense that the project may be a failure. All these factors should be considered in ranking projects in a preference ordering before a public decision has been made.

How has the benefit-cost analysis been used in water and resource allocation? Usually a benefit-cost analysis of a project has been made after all the plans have been completed. Using the analysis in this manner is not using the analysis efficiently: "economic principles must be applied at every state of project planning and design and not just after the project is planned."[1] Using the benefit-cost analysis just after the planning of the project is completed does not aid in planning and is not likely to lead to good economic results. It only helps justify the project.

How are we to treat the different tangible costs and benefits? Excluding intangibles, the value of the

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[2] *Ibid.*, p. 365.

tangible benefits is an imputed value, that is, not the price charged for water, but rather the extra income less the extra costs of those who use the water; for example, farmers benefiting from irrigation projects. The cost of a project is just the process of measuring the tangible costs incurred in constructing the project, but here there is some difficulty. These difficulties in measuring tangible costs will be dealt with shortly. Other costs which may be incurred in a project are of an intangible and external nature and shall be dealt with in the section dealing with the treatment of externalities which presents many problems to those conducting a cost-benefit analysis.

Secondary benefits and costs also present a problem to those conducting a cost-benefit analysis. They usually require a great deal of time to trace and they are very difficult to evaluate. But generally where projects are similar, their secondary benefits and costs may be excluded since they are usually similar. But where projects have different locations and provide different services, it may then be necessary to consider secondary costs and benefits. This problem will be dealt with much more thoroughly in the section on secondary benefits and costs.

Problems in Measuring Tangible Costs and Benefits

Generally in water resource projects all costs and benefits are measured in terms of current prices. Very seldom

is a change in either absolute or relative prices accounted for in the evaluation of the project and future prices are very seldom the same as current prices. These prices may change for any number of reasons, one of which may be a general price level rise, which may not cause relative prices to change, but over time relative prices do change. As Professor Schramm points out: "In the case of electric power supplies . . . the changes in relative prices on the cost side and the currently so important problem of expected changes in relative prices on the benefit side turn out to be much more important than the general upward drift in prices."[1] Relative prices obviously do change and have a very important effect on a cost-benefit analysis and therefore on the rankings of projects.

First examine the effect of a general price level on the costs and benefits of a hydro project. Usually the cost of a hydro project is largely capital expenditures in the early stages whereas the benefits accrue over the life of the project. Given a rise in the general price level, the benefits will be clearly understated if only current prices are used. Also very often interest rates reflect expected price

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[1]Gunter Schramm, "Real Costs and Real Benefits Under Present Federal Water Resources Evaluation Procedures," a paper presented at the Eighth Annual Meeting, Western Regional Science Association, Newport Beach, Los Angeles, Calif., February 7-9, 1969, p. 2.

increases, therefore the costs are adjusted for price increases since the funds for capital expenditures are borrowed. Now the cost-benefit ratio will be seriously under-estimated and this may actually lead to the elimination of projects which would be economically efficient. One method used to overcome this problem could be to evaluate the project in terms of current price levels and adjust the interest rate downward.

Relative price changes present a more difficult problem to the analyst. To discuss the cause of relative price changes or any price change is beyond the scope of this paper. Relative price changes are only of interest insofar as they affect water resource projects.

On the cost side of the project, the cost of construction changes very rapidly. For example, construction costs have been known to vary 20 to 30 per cent for identical equipment over a period of four to five years.[1] This would have a very large effect on the cost of a project. For example, Professor Schramm has investigated three hydro projects in the Yukon and has estimated the effect of changes in construction costs on each project.[2] He has assumed construction costs will continue to rise at the same rate as in the past. In the first hydro project construction would continue for

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[1] Ibid., p. 7.

[2] Ibid., p. 9.

some 57 years, in the second some 47 years, while in the third case construction would only continue for six years. Increases in required mill rates to cover construction costs under inflation in the first case is 72.9 per cent, while in the second case it was 30.7 per cent, and in the third case it was only 4.8 per cent. "These are substantial differences indeed which very radically alter the respective evaluation of the two projects. Trends in construction costs, therefore, cannot be disregarded in cases where construction times are long."[1] The result and particulars of the investigation have been reproduced in Table I so one can see more clearly just how the figures were arrived at and the importance of construction costs.

TABLE I

THE EFFECTS OF A TWO PER CENT ANNUAL RISE IN CONSTRUCTION COSTS ON THE EVALUATION OF THREE HYDRO PROJECTS[2]

Project	Total Construction Costs in 1964-dollars (millions)	Projected Construction Period (years)	Average Costs/khw No Inflation	Average Costs/khw Inflation 2% per year	Increase in required Mill Rate % (Col.3=100)
Case I	1,905	57	5.35	7.34	72.9
Case II	1,882	47	3.52	4.60	30.7
Case III	1,282.9	6	2.90	3.04	4.8

[1] *Ibid.*, p. 9.

[2] *Ibid.*, p. 10.

> This issue is particularly critical of cases of long-term development programs that consist of a number of individual projects which for their feasibility, depend on a costly common feature or component. In such cases the initial decision to proceed will often depend on the benefit-cost analysis of the whole program. But once the common component has been built even large cost changes for the remaining projects may not deter their construction simply because their, in terms of the overall development program, 'marginal' benefit-cost ratios may remain above unity despite the fact that the average benefit-cost ratio for the development as a whole may have been reduced to less than one.[1]

Changes in operating costs because of inflation may also be of great importance when evaluating projects. In hydro projects, technology is usually fixed, for the most part, over the life of the project. As the economy progresses and labor productivity increases, wages will rise as they should so as to gain some of the increased benefits and to cover for inflation. But in hydro plants the technology is somewhat fixed so one can assume the productivity of the plant has remained fairly constant. Now wages have increased and so have the operating costs. This could have a very large effect on cost-benefit analysis, especially if one is making a choice between two similar projects, yet one is capital intensive while the other has labor involved to a greater extent.[2] Therefore, in carrying out a cost-benefit analysis the analyst must somehow incorporate increases in wages and other prices into the analysis.

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[1] Ibid., p. 11.

[2] It has been assumed there is no substitution between capital and labor.

Changes in technology, especially in hydro projects, are of great importance and changes are taking place at a very rapid rate. Better machinery and more efficient methods are being discovered very quickly making existing hydro plants obsolete before their life has come to an end.[1] This must also be incorporated into a benefit-cost analysis and maybe hydro projects having the shortest life span could be accepted if they are economical. In this way the project could take advantage of advancing technology.

"We must conclude that the prevailing practice of evaluating benefits and costs in terms of present costs and prices is not only likely to lead to an understatement of actual costs, but may also lead to gross inefficiencies in project selection."[2] Somehow future costs and prices must be estimated and incorporated into a benefit-cost analysis. Even though this introduces new uncertainties into project evaluations, as long as the estimates of future costs and prices point in the right direction and as long as the estimates are backed up by a sensitivity analysis[3] that tests the effects of the assumptions on overall benefits and costs

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[1]Hydro plants become important for providing peak loads.

[2]Ibid., p. 17.

[3]A sensitivity analysis is one in which the analyst observes the effects of different assumptions on the benefits and costs of a project. For example, the analyst may wish to observe the effect of different price changes on benefits and costs.

the estimates of benefits and costs will be better and more realistic compared to estimates of benefits and costs using present costs and prices.

II. The Conceptual Problems of Cost-Benefit Analysis

A. Treatment of Externalities. Externalities are activities of a decision-making group which affect the activities of other groups without directly affecting the decision-making group. Such externalities may be labelled external economies or external diseconomies. These refer to changes in the costs of a firm resulting from an expansion by another firm or industry. An increase in costs to the other firm would be an external diseconomy; a decrease in costs would be an external economy. These changes in costs may be caused by a technological or pecuniary spillover. If the actions of a firm affect the physical production possibilities of other firms or the satisfactions that consumers can obtain from given resources, then the externality is said to be caused by a technological spillover. If the external affects are via prices or factor prices, then the externality is said to be caused by a pecuniary spillover.[1] The question to be asked is how should these externalities be treated in a benefit-cost analysis?

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[1] R.N. McKean, Efficiency in Government Through Systems (New York: John Wiley and Sons, 1958), p. 138.

First examine the technological spillovers. These spillovers affect the physical production or consumption of people other than the progenitors of public or private investment. One example of this type of spillover would be the pollution of the atmosphere and water by industry.

Ideally, firms and projects should take these externalities into account and, in some cases, industries have been compelled to take steps to eliminate serious external effects. But it is not economical or practical to trace all the external effects and to adopt measures to take them into account.[1]

From these previous examples, the implications for cost-benefit analysis is clear. In water resource projects, the government should consider in their cost-benefit analysis the external costs and benefits which result from technological spillovers, if such costs and benefits can be predicted and priced. But we must distinguish between external technological spillovers which are worth counting and those which are trivial from economical and practical reasons.

There are other external spillovers which do not affect physical inputs of either the firm or consumer. These external spillovers are caused by shifts in prices which fall

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[1]Many externalities are too trivial or uncertain to be taken into account, but nevertheless should be listed in a cost-benefit analysis.

into different groups with different characteristics.[1] Such external spillovers are called pecuniary spillovers.

The first type of pecuniary spillover to be dealt with is an expansion in an industry causing the prices of factors used in that industry to be bid up. This will cause the costs to rise in other industries which use this input. Are these losses to other firms a cost which should be considered in a cost-benefit analysis?

Let us look at the expansion in the industry. In order for an industry to expand, consumers must be willing to pay for the output and the price of the output must be more than the price of the input. Because of the increased demand for both input and output, the prices of each will rise and inputs will be bid away from other industries. Resources are being reallocated by consumer preferences to where they are more valuable. Therefore as far as efficiency in the economy is concerned, the expanding industry should not be made to consider the cost to other industries. This also applies to a cost-benefit analysis as is pointed out by R.N. McKean in the following:

> The measurements should not reflect this type of pecuniary spillover in order to show the way to an efficient

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[1] R.N. McKean has divided these spillovers into four groups which simplifies the analysis somewhat and I shall follow the same procedure.

> set of projects. . . . Moreover, there is little use in talking about compensation of everyone who is injured . . . an announced policy of compensation could eliminate a good deal of desirable readjustment.[1]

Another pecuniary effect could be on the price of substitutes. Suppose the supply of hydro-electric power increased, causing the price to decrease. For other substitutes, such as oil and gas, this means a price decrease causing lower profits to firms producing the substitutes. At the same time certain consumers benefit from the lower price. Should such costs be considered?

This case is very similar to the previous case where inputs were reallocated to where they were more valuable. Therefore the costs should not be counted as costs or a reduction in benefits in a cost-benefit analysis. "The benefits are whatever the bidders are willing to pay for the incremental output of the project; <u>the costs are whatever must be paid to attract the extra inputs that go into the project</u>."[2]

Another type of pecuniary effect is an expansion in one industry causing an increase in demand and price for the complementary good. Again resources will be attracted from other industries into the industry with the increased demand. Some industries, as a result, will incur losses and others

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[1] R.N. McKean, <u>Efficiency in Government</u>, p. 138.

[2] <u>Ibid</u>., p. 139.

will experience gains. The analysis will follow much the same as the previous and the losses to other firms will not be considered as costs in a benefit-cost analysis.

Also an expansion in an industry may cause the price of the output to fall. This will cause wholesalers and retailers or whoever it may be holding an inventory of the product at the old price to incur a loss. They purchased the goods at the old price but must sell at the new, lower price in order to compete, thus incurring a loss. But consumers who use the output will benefit. In this case the benefits should be the increased output multiplied by the new price and should not be decreased (increased) to reflect losses (gains). These losses can be ignored in order to determine, with the help of a cost-benefit analysis, which investment gets the economy closer to maximum production. "What people are willing to pay for the incremental output is still the measure of its worth, and what has to be paid to attract the inputs is still the measure of its costs."[1]

But a cost-benefit analysis should not overlook the fact that other firms will retaliate; that is, if the price of the output is decreased, other firms may lower the price more making the investment less profitable. This retaliation

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[1]*Ibid.*, p. 140.

on the profitability of the proposed investment can be estimated by examining the proposed investment in the appropriate context, that is to say, within the framework of game theory or a similar idea. But to consider transfers arising out of an investment as gains or losses of that proposal would not lead to the correct investment.

> The pecuniary external economies are not social benefits since they are transfers of rent among specialized factors. The gains to one group are off-set by the losses of another group. . . . (T)here is no net increase in the efficiency of the economy.[1]

How clear is the distinction between the technological spillovers and the pecuniary spillovers? The two spillovers can become confused very easily if one thinks of pecuniary spillovers as a transfer of income in which some of the transfer may be attributed to changes in capital values. But a technological spillover may also be caused by a change in capital values, the difference being a technological spillover affects other producers' physical inputs whereas pecuniary spillovers do not. "The distinction really rests on the following basis: technological spillovers affect the physical outputs that can be obtained from other producers'

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[1]J. Margolis, "Secondary Benefits, External Economies, and the Justification of Public Investment," The Review of Economics and Statistics, Vols. 39-40 (1957-1958), p. 288.

physical inputs, while pecuniary spillovers do not."[1]

The distinction is still difficult if an investment creates both types of spillovers. In this case it becomes hard to unravel the spillovers, but the distinction is still there and it is only the technological spillovers which should be counted. Another problem arises when the pecuniary spillovers induce technological spillovers, but, again, only the technological spillovers should be counted if we are to choose the investment which is most efficient.

How does this treatment of pecuniary and technological spillovers compare with other treatments of these two affects? One approach used has been that of maximizing national income. This is essentially the same as maximizing efficiency and production given a particular distribution of wealth and therefore prices. But maximizing national income would mean maximizing national income as it is measured. This could lead to the same choice of investments as would be chosen by the suggested method--that is maximizing the incremental revenue minus its costs. But this may not be true in every case. National income, as it is measured, may be changed from a shift from one set of prices to another or by a number of pecuniary effects, in which case investments chosen to maximize national income will count pecuniary effects as

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[1]McKean, Efficiency in Government, p. 143.

benefits and costs. Since many transfers and pecuniary spillovers do cancel out when we measure national income shifts, the suggested method may be consistent with that of maximizing national income.

Another approach in selecting efficient investments is the common sense approach which suggests we do not duplicate existing facilities because it is uneconomical. Is it necessary to count the fall in rents of existing facilities as costs, therefore making the investment uneconomical? No, this is not the case. Only the cost of the incremental output is to be counted as a cost of the output. The fall in rents of existing facilities need not be considered as a cost. But the analyst must remember that the existing facilities need only consider operating costs. Since their capital is already invested, they may be able to set prices below the cost of the output of the new investment. The analyst must consider his competitor in estimating the value of the benefits, but does not have to include the decline in rents of existing facilities as costs. A duplicate may very well be economical.

New investments, more efficient than existing investments, attract resources and sales from other firms. Some resources will not be transferred and as a result will receive lower rents. Losses may be incurred by the resources which receive lower rents while those who are transferred will be

used more efficiently. Yet these losses are not counted. "We are concerned with gains and costs from the standpoint of the whole economy. If we approve of consumers' sovereignty, then the measure of gains to the country is what people are willing to pay for the new output. The measure of costs--what the whole economy must give up--is what the new producer has to pay."[1] Essentially, this states that the technological spillovers should be counted while pecuniary spillovers should not be counted.

B. Treatment of Secondary Benefits. "Since the main objective of most benefit-cost analysis is to compare the relative merits of projects which are close alternatives, in most instances the practical evaluation can be confined to assessing the primary and direct costs and benefits."[2] Secondary benefits to be counted depend largely on the projects and on how marginal their cost-benefit ratios are, but there is general disagreement on the treatment and meaning of secondary benefits. There does not exist a clear definition of secondary benefits, but the Federal Inter-Agency River Basin Committee has proposed a definition which will be sufficient for the purposes of this thesis. "Secondary benefits . . . are the values added by incurring secondary costs in

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[1] *Ibid.*, p. 149.

[2] Sewell, *Guide to Benefit-Cost Analysis*, p. 18.

activities stemming from or induced by the project."[1] The benefit stemming from the project is the net income derived by transporting or selling the products from the project. The benefit induced by the project is the net income derived by supplying materials and services to the project.

Now the problem arises as to how these secondary benefits should be measured; that is, what should be included in the calculation of secondary benefits? The U.S. Bureau of Reclamation presents the secondary benefits in the following detail with reference to irrigation projects:

> 5. Indirect irrigation benefits comprise the increase in:
> A. Profits of local wholesalers and retailers handling increased sales of farm products consumed locally off the project without processing.
> B. Profits of all other enterprises between the farm and the final consumer, from handling, processing, and marketing increased sales of farm products locally and elsewhere.
> C. Profits of all enterprises from supplying goods and services for increased farm purchases for family living and production expenses.
> D. Land value of local residential property.
> 6. Like direct farm benefits, indirect irrigation benefits will be calculated from summaries of farm budget data representing future conditions with and without the project. Indirect benefit factors will be applied to increases or decreases in the value of individual commodities listed in the budget summaries. The indirect benefit from increased land value of local residential property will be calculated separately.
> 8. Improvement in non-commercial land value of property in towns on or near irrigated areas will create an

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[1]Margolis, Secondary Benefits, p. 284.

> indirect benefit to persons other than project farmers. For example, twenty acres of unimproved land worth $100 an acre might be subdivided for residential purposes and sell for $800 an acre. Higher-grade use of the land would then have increased its value from $2,000 to $16,000. The indirect benefit would be four per cent of $14,000 increase or $560 per year.[1]

But, as McKean points out, these terms are not used consistently. The Bureau of Reclamation considers the wages of men who were hired because of the project as direct benefits.

Now comes the controversial question as to whether or not these secondary benefits are gains to the whole economy. Secondary gains such as wages, incomes to suppliers are counted as secondary benefits, but should they be included in benefit-cost analysis? If they are, costs of the project become gains and the benefit-cost ratio can become extremely high.

Thinking of private investments for a moment, why do they not include such secondary benefits as gains? They do not include such benefits as gains because they should not be included if resources are fully employed--from the standpoint of economic efficiency.

> The payments for additional inputs, which increase the firm's production, are relevant, but, since these

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[1] *Ibid.*, p. 285.

> resources are drawn from marginal uses, these payments represent what the resources would be worth in alternative uses. The only new value contributed by the project, to be compared with its costs, is the amount which the buyers of the new output would be willing to pay.[1]

But if resources would be otherwise unemployed without the project, then the secondary benefits may be counted as gains, but only over the length of time the resources would be unemployed. This is because benefits, such as increased aggregate demand arising from increased employment would only be an advantage during a period of unemployment.

What implication does this have on a cost-benefit analysis? The Federal Inter-Agency River Basin Committee has suggested that the extent of unemployment be projected and the secondary benefits be calculated as gains; that is, calculate the net income of resources without the project. This view is in essence conflicting with that of McKean.[2]

McKean does not seem to disagree with this method on a logical basis, but on a basis of the degree of certainty in this method. First he points out the difficulty in predicting the amount of unemployment and under-employment with and without the project, especially if it is a long range forecast which is the case if we deal with water projects.[3] If

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[1] McKean, Efficiency in Government, p. 158.

[2] Ibid., p. 160.

[3] Ibid., p. 160.

unemployment forecasts are only for short periods, then the benefits will be trivial in comparison to the projects' benefits, therefore having little or no influence on the ranking of projects.

McKean also finds it very difficult to predict the effects of a project on employment especially when the rest of the federal budget is unknown. This prediction would be made with very little certainty, especially when the effect of the water resource budget on taxes and other government expenditures is also unknown.

Another source of uncertainty would be caused by the fact that the analysis is prepared well before the decision to go ahead on the project is made. If unemployment were to exist nationally before the project began and was decreased after the project ended, then secondary benefits should be counted as gains to the economy. Yet it should be remembered that secondary benefits should only be counted as national gains if unemployment does exist.

What about the value of secondary benefits in regional growth?[1] Most of the secondary benefits arising from a project occur in the region in which the project is located. This stimulates regional growth and should be counted as a

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[1]*Ibid*., pp. 162-163.

gain to the region if the region is underdeveloped, that is, if it has idle resources. National secondary benefits, as opposed to the regional viewpoint, are not as important in that they are more difficult to identify and they are probably off-set somewhere in the economy--i.e. a project hires resources, but if there is full employment, resources must be attracted from other industries, therefore not being a benefit from a national point of view since unemployment has not been decreased. Also if one project was not undertaken, there would possibly be other projects undertaken somewhere else which would have similar secondary benefits.[1]

> Where secondary effects are evaluated, they should be treated as additional considerations quite separate and less precisely defined than primary effects. Quantitative appraisal of the secondary effects of a particular project is quite apropriate but such estimates should be treated with caution because these effects are difficult to identify and to measure.[2]

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[1]Intangible effects may play an important role in ranking projects especially from a regional viewpoint as well as national. But it may be very difficult to put a monetary value on these effects; nevertheless an effort should be made to quantify them as far as possible where they have an important effect on decision-making.

[2]Sewell, Guide to Benefit-Cost Analysis, p. 18.

CHAPTER III

INPUT-OUTPUT ANALYSIS

The purpose of this chapter is to probe into the use of input-output analysis in identifying the effects of pecuniary externalities and secondary benefits on the regional economy in particular and the economy in general. Large scale water projects have a macro-dynamic effect on the economy, usually extending far into the future. These effects are usually the result of pecuniary externalities and secondary benefits which a cost-benefits analysis does not consider important. Input-output analysis will then be examined for its ease and usefulness in estimating these pecuniary externalities and secondary benefits.

Introduction

Input-output analysis was originally developed by Professor Wassily Leontief. The original table displayed the economic technical interdependence of every sector of the economy. This method of analysis has become widely used today, both on a national and regional basis. The small-area input-output models may deal with a single region or may take on an interregional characteristic.

This tool, developed within the last century, fits

very nicely into economic statistics, or more exactly into econometrics. The model itself may become very difficult and highly mathematical when the interdependence of the economy is described in detail. But for the basic idea underlying the input-output model, the explanation need not be complicated by mathematics. In the brief description of input-output analysis which follows, the mathematics will be deleted and only a very simplified explanation of input-output analysis will be given.[1]

Input-Output Models

Essentially, an input-output model shows the connections between all the sectors of the economy. The input-output table shows how the output of each sector is distributed among other sectors of the economy and how the inputs of each sector are outputs of the other sectors. For this reason, input-output models may be very useful in showing the effects of a water resource project on the economy.

The input-output model may be as detailed as desired so the expansion in the economy due to a water project may be followed through different industries and sectors. With

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[1]For a simplified, but very thorough explanation of input-output analysis, a suggested reading would be William H. Miernyk, The Elements of Input-Output Analysis, from which most of this chapter is taken.

this approach bottlenecks can be located during the expansion which may cause prices to rise or have some other adverse affect on the water project. Insights such as these will be revealed in a detailed input-output analysis and would not be revealed in a cost-benefit analysis. The input-output analysis can be a significant aid in the planning of the project, bringing the economy closer to maximum production in the most economical way possible.

Using input-output models as an aid in planning water resource projects is helpful, but the method itself has a number of drawbacks which must be considered. Data needed for the model is very difficult to collect. The labor and cost of collecting this data can be great, therefore limiting the use of the model. But once the model is constructed, it is very easily understood and followed.

After the input-output table has been constructed, one can derive technical coefficients. By technical coefficients is meant the amount of inputs required from each sector to produce one dollar's worth of output. With these technical coefficients the amount of direct purchases required from each sector as a result of an increase in demand for output of one sector can be calculated. By making use of such technical coefficients, officials of the water resource project can tell what effect the project will have on other industries and regions within the economy.

This does not represent the total addition to output resulting from additional sales to the final demand sector. The increase in demand will lead to both direct and indirect increases in the output of all industries. The indirect increases in output are caused by the increase in demand for output by industries who experienced the increase in final demand and so on as outputs of one sector are inputs of another sector. The effect appears to be much like a multiplier effect.

Deriving these technical coefficients for the direct and indirect effects is an integral part of an input-output model. It shows the total expansion of input in all industries as a result of the delivery of one dollar's worth of output outside the processing sector. This table must have no negative entries. This would mean that every time an industry expanded its output, its need for inputs would decline; an obvious economic contradiction.

Regional Models

Before World War II, input-output models were only used for national purposes. After the war, regional research became dominated by input-output models. The regional input-output model is similar to that of a national input-output model, but covers a smaller geographic area. Some interregional input-output models have been devised which include more than one region. The interregional model gives a

fairly clear picture of the flows between regions and with the use of the technical coefficients, the effects of a project on the flows and ultimately on the economic growth of the region and country as a whole can be determined.

Interregional models are much more complex than national or regional models because the interindustry interdependence and interregional interdependence must be blended. To date, economists have had very little success with this model because of the lack of detailed data on industry purchases and sales by region. If reliable data were available in detail, this interregional model could be very useful. It would show how changes in demand in one region would affect other regions. This type of information would be very valuable in analysing water resource projects, especially the benefits which are of the secondary nature. But because of the difficulty in obtaining data, most regional studies use the balanced regional model which is just a national model disaggregated into regions.

One variation of an interregional model was developed by Isard for the Colorado River Basin which consisted of a series of six input-output tables, one for each sub-basin of the larger river basin. Isard constructed separate regional input-output tables for each of the six sub-basins and linked the tables together by import rows and export columns. Through this linkage it is possible to show how a change in

demand in any one sub-basin will affect the level of activity in other sub-basins. This method used by Isard is one conceivable way of overcoming the complexity of the interregional model but yet keeping all the advantages of the interregional model.

Regional input-output studies differ significantly from interregional analysis. The basic model used in regional studies is similar to that used in the construction of national input-output tables with the exception that regional models are usually made to suit local conditions. Also regional models are more open than national models because regions are more specialized and trade accounts for a greater proportion of the transactions.[1]

In regional input-output models, there are two basic types. One type of regional model, much like the national model, has the import and export columns highly aggregated. In the second type, imports and exports are disaggregated by industry and sector. This second type shows the interindustry transactions within the region and also the detailed interindustry transactions between this region and another

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[1]Open in this context refers to trade with other sectors of the economy. Because regions tend to be specialized in production, the region will depend on other sectors of the economy for other goods and trade will account for a large part of the transactions in the input-output table.

region. This type of model is very useful in a structural analysis. The model shows sources of demand and the affect of increased demand on other industries and regions.

These regional input-output models are primarily used in making regional impact studies and have a slight advantage over interregional models in that they are not as complex, but data is still very difficult to obtain; for example, regional technical coefficients cannot be calculated without incurring high costs and a large amount of labor. Instead of calculating regional technical coefficients, national input coefficients are used. "The result in each case was a table of interindustry flows based on the assumption that regional input patterns were identical to national input patterns. This assumption imposes a severe limitation upon the use of such input-output tables for analytical purpose."[1]

Use of Input-Output Models in Forecasting

"Local and regional impact studies are designed to measure the direct, indirect, and induced income and employment effects of changes in final demand in one or more sectors of the local or regional economy."[2] In the case under consideration here, the change in final demand would be caused by water projects. This impact study could conceivably give

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[1]William H. Miernyk, The Elements of Input-Output Analysis (Random House, New York: 1967), pp. 66.

[2]Ibid., p. 69.

some insights into the effects of water projects on the economy in general and especially on the regional economy in particular. The effect on the growth rate of the region and other benefits could be traced through the model and be a very important factor in evaluating the project. The input-output model would and should be an asset and aid in planning the project along with their use in projecting future economic conditions such as the amount of unemployment with the project and the amount without the project. Secondary benefits influencing economic growth could then be projected with the use of input-output tables with much more certainty. Also relative price changes can be predicted with more certainty and the effect of these price changes on costs and benefits can then be predicted.

Input-Output Analysis and Forecasting

To forecast consistently one must remember two major steps; first it is necessary to project each sector's final demand, second, from this a new transactions table in the input-output model is projected on the basis of the projected final demand. But now there is the problem of allowing for change in structural coefficients when long term projections are needed such as in large scale water resource projects. For short term forecasts it is fairly safe to assume that the input coefficients will not change, at least not significantly. But in making long term projections this cannot be assumed.

Now a dynamic input-output table is required which will be discussed later.

From this new transactions table, consistent forecasting sounds simple. With an up-to-date input-output model, short term consistent forecasting is relatively simple.[1] The accuracy of the interindustry projections will depend upon the accuracy of the final demand projections. But even when there are errors in final demand projections, the interindustry forecasts may be useful. For long term forecasts, the table must be made dynamic to account for relative price changes, the entry of new industries, and technological changes. These three occurrances affect the technical coefficients in the table and change the projections. Therefore the effect of each must be estimated and accounted for by making the model dynamic.

First, changes in relative prices and their effects on coefficients will be examined. If relative prices change during the period of projection, then it is possible that input mix and therefore technical coefficients will change; but inputs must be substitutes as the case may be between labor and capital. If labor prices rise while capital prices

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[1]For a detailed study on economic forecasting see: Jacob Mincer, Economic Forecasts and Expectations (New York: Columbia University Press, 1969).

remain approximately the same, then capital may be substituted for labor. This may affect a number of input coefficients. The share of total payments to labor declines, and when more machinery is used, inputs of electric energy will be increased. These affects must be taken into account in a long term projection, if it is to be accurate.

The appearance of new industries may also throw the long term projections off to some extent. For example, the development of the computer industry during the 1950's had a very large effect on input coefficients and if technical coefficients did not account for this, then projections would be incorrect by a considerable degree.

Technological changes are bound to effect technical coefficients and static input-output models do not account for such changes. This is the most serious criticism of long term static input-output models since in these types of models it is assumed that the technical coefficients are fixed; indeed, the long term technological developments are bound to occur and affect input patterns. But these technological changes are easier to account for in the input-output model than the other types of changes. The input-output model must be made dynamic in order to account for the technological change in the long run. This operational dynamic input-output model will improve the accuracy of forecasts and will permit longer term forecasts. Making this model dynamic in such a way as

to be of use in water resource projects is a difficult task. But first let us look at how the static model can be of help in water resource projects using short term forecasts.

The Static Input-Output Model and Water Resource Projects

With an input-output model a detailed projection of output for the economy can be made. For example, if the main aim of the water project is irrigation, then the first step would be to project the final demand for farm products. Then from the input-output model, the demand for fertilizer, labor, farm machinery, steel and so on can be forecasted. From this the primary benefits of the project can be determined and with knowledge of future idle capacity in the economy, secondary benefits may also be determined with much more certainty and consistency than under a cost-benefit analysis. This provides a very helpful guide to decision makers.

To be helpful to decision makers economists must determine the best way to measure the impact the project has on employment, income and output. Here we are interested in the details of the overall impact rather than just the multiplier effect. For example, in the water resource project there will be an immediate impact on the construction industry but how will this impact affect other sectors of the economy? Through the input-output model, the impact on other industries most directly affected can be measured with little difficulty. Increased employment and income can be measured with a fair

amount of ease when a detailed input-output table is used. The detail of the table will depend on the amount of information wanted and the desired detail of the information.

To obtain information on income from the input-output table we must develop sectoral multipliers. To do this the transaction table is closed with respect to households; that is, households are moved into the processing section of the table from the final demand section. Now a new table of technical coefficients must be calculated. The household technical coefficients will then give us the value of labor needed to produce one dollar of final output. This new table also provides us with information about the degree of labor intensity in each industry.

The next step in making an input-output multiplier analysis is to compute direct and indirect requirements per dollar of final demand including households in the processing sector. This then shows the total dollar production directly and indirectly required from the industries and households per dollar of final demand. It is now possible to compute income multipliers for the industries in the processing section. Two types of multipliers may be computed. The first type is just an income multiplier since it just takes into account direct and indirect changes in income resulting from an increase of one dollar in output. The second type of multiplier is more realistic. It takes into account the

direct and indirect effects indicated by the input-output model plus the induced changes in income resulting from increased consumer spending. The second multiplier will always be larger than the first.

What information will these multipliers give us which could be helpful in planning water resource projects? From them we can observe different amounts of income generated by different industries even though the output of each industry expands by the same amount. The first type of multiplier merely reveals the direct and indirect effects on income when output is expanded, but the second type of multiplier shows "the chain reaction of interindustry reactions in income, output, and once more on consumer expenditures."[1] Through these multipliers it is possible to predict the effect the water project will have on income of both those directly involved with the project and directly benefitting from the project, i.e. farmers and others such as merchants and suppliers indirectly involved with the project.

Income changes through the multiplier effect will be much larger the greater the interdependence within the economy and the lesser the economy depends on imports. Also large direct income changes are not associated with large multipliers because the indirect effects may be smaller. Why is

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[1] Ibid., p. 48.

this the case? The reason seems to be that if an industry which depends to a large extent on labor and not on many other inputs it will probably have fewer transactions with other industries. An industry which utilizes a considerable amount of capital equipment will usually have many transactions with other industries. When industries use a great deal of capital, the multiplier effect will be larger since the effect will be felt in other industries and in a larger part of the economy.

There are a few technical problems in computing these multipliers which place some limitations on the use and significance of the multipliers and should therefore be recognized. The first problem, especially with water resource projects, is the regional basis on which the desired multipliers must be empirically based. But because of lack of data on consumer spending patterns in regions, we are faced with the problem of derivation of multipliers. This may be overcome by using national data or by assuming consumption expenditures are proportional to income.[1] But here the consumption functions are aggregate and may very easily overstate the income effects of change in final demand. Yet these sectoral multipliers are

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[1]Frederick T. Moore and James W. Peterson, "Regional Analysis: An Interindustry Model of Utah," The Review of Economics and Statistics (Vol. 37, November, 1955), pp. 376-377.

more useful and revealing than aggregate multipliers for many analytical purposes.

It is also desirable to estimate the employment effects of water projects. Once the required input-output model has been constructed, employment multipliers may be constructed which will help in estimating the employment effects of the project. This employment multiplier is based on the attraction of industries to the general area in which the water project is located. These industries will be attracted to the general area because the hydro power is an important input in the industries, or if it is an irrigation project, industries will be attracted to the area because farmers are their main market or their products are farm inputs.

The first step in deriving the multiplier is to estimate the number of industries attracted to the area. The shift in production from other areas must also be estimated since this will decrease employment in other areas of the economy. Next production-employment relationship must be estimated and the estimate of the amount and kind of inputs used by each industry. In estimating the use of inputs, an input-output table is utilized. Each of the coefficients in the table is multiplied by the dollar volume of expected production. This results in the total input requirements. Now from these input requirements, it must be estimated how much will be produced in the area. The employment multiplier is

now derived by computing a series of rounds of expansions. The first round was computed by applying the percentage of input requirements to be produced in the area to the total input requirement. This procedure was applied successively until several rounds have been computed. After the rounds have been computed, sum to find the total of the expansions. Then from the employment-production relationship, employment is estimated.

Dynamic Input-Output Models

For long run projections from an input-output model to be accruate it must be made dynamic, otherwise the projections could be quite misleading because the economy most likely has experienced some structural changes with technological advances. The static input-output model assumes fixed technical coefficients and does not allow for structural changes. These fixed coefficients assume constant returns to scale which is highly unlikely in most industries. For this reason input-output tables are very useful for describing the structure of the economy but economists have criticized the value of its predictive content mainly because of its static nature.

The development of the empirical dynamic input-output model is still in the early stages but methods have been suggested for the dynamic model. The link between the dynamic input-output model and the static input-output model is a

table of incremental capital coefficients. For a complete dynamic model, other changes must be accounted for, such as shifts in demand. But the major requirement for industrial analysis is a complete description of the capital structure of the economy. But in this section a simple dynamic model, not depending on capital coefficients, will be described. "The model is based on the assumption that at any given time some establishments in an industry are more advanced than others, and that the input patterns of the 'best practice' firms in an industry can be used to project the average input patterns of that industry at some time in the future."[1]

> The assumption is made that long-run changes in technical coefficients are due to a combination of changes in relative prices and technological progress, and that these changes will be reflected in the technical coefficients of the 'best practice' firms during the base period. It is also assumed that the technical coefficients will be affected by changes in interregional trade patterns, and that some of these changes can be anticipated by analysis of long run trends.[2]

In describing the method by which the dynamic input-output table is derived, Miernyk's description and example will be followed very closely.[3]

The first logical step would be to identify the 'best practice' firms in the industries with which we are concerned.

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[1] *Ibid.*, p. 117.

[2] *Ibid.*, p. 117.

[3] *Ibid.*, pp. 118-125.

First we must assume firms comprising an industry produce identical products, but their inputs are not the same. Also these firms will be of different ages, some of which will use older equipment and employ less efficient production processes. "In brief, the technical coefficients of a static input-output model represents the average input patterns of all the firms in the industry."[1] But there will be a large variance of technical coefficients around the average. Miernyk's idea is to "identify a sample of firms which are above average in terms of productivity on the assumption that this sub-sample of firms will be representative of the average firm at some time in the future."[2]

Now the productivity of the firms must be measured. This may be done by expressing outputs in terms of man-hour inputs or outputs in terms of combined capital and labor inputs. From either one of these methods productivity ratios can be derived. Now the firms are ranked by their productivity ratios. When the input coefficients of the firms above the average are computed, the results are then considered representative of the average technical coefficients of the industry at some future time.

From the new technical coefficients, a new table of

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[1]Miernyk, Input-Output Analysis, p. 118.

[2]Ibid., p. 118.

direct and indirect coefficients per dollar of final demand can be computed. The new table of direct and indirect requirements per dollar of final demand is then applied to the final demand projections to obtain a table for interindustry transactions for a future year.

This simple input-output model could be made more dynamic. The model requires a certain amount of judgment, for example in selecting the best practice firms. Also it is not certain that the input patterns of future firms will resemble the input patterns of the best practice firms now. This model merely gives a set of projections which typically have a margin of error in a free-market economy. But even with this margin of error, because of the judment involved, the dynamic model with changing coefficients could result in better projections than the projections resulting from a static model.

Input-Output Models Improved With Specialized Coefficients

Input-output models have been used in predicting even though they are static. Every forecast has a certain margin of errors because of uncertainties, but this margin cannot be too wide. Then why have input-output models been used in predicting? Other methods of predicting deal with aggregates which have limited use, whereas input-output models deal with industries and sectors in detail, making them much more useful. When compared to the multiple-regression method,

this margin of error in static input-output models was reasonable and the input-output model has come off quite well.[1] But the input-output models still need improving.

We can improve the input-output model by introducing specialized input coefficients. For example, if we derive labor input coefficients which show labor inputs, in physical terms, per unit of output, then one can derive employment effects of a project. Another example of a specialized coefficient is a water-use coefficient. This coefficient gives the amount of water needed per unit of output in different industries. For water resource projects, this coefficient could be very useful. Water needs could be projected into the future and we would be able to predict with much more certainty the type of industry which will be attracted by a water resource project and also employment benefits. But because the input-output model "is limited to the flow of current transactions and because of its fixed coefficients, the applicability of the static model is limited to short-run analysis."[2] For use in long run predictions we must work with a dynamic input-output model.

The Need for a Macro-Dynamic Input-Output Model

Most large-scale water resource projects are of a

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[1] Ibid., pp. 112-113.

[2] Ibid., p. 113.

long term nature and affect more than one region of the economy and may affect the economic growth of the whole economy. For this reason a method of analysis which is macro and dynamic is needed. Without these two characteristics, the total effects of the water resource project cannot be projected nor can an estimate of the macro secondary effects both stemming from or induced by the resource project.

Input-output analysis has the advantage of being able to trace pecuniary externalities and secondary benefits of water resource projects assuming the benefits are subject to the operation of the price mechanism. These pecuniary externalities and secondary benefits usually are of a macro nature, affecting more than one sector of the economy and more than one industry. The input-output model can be constructed to cover as large a region as one wishes and as many industries as one wishes. It can be highly aggregated, as it usually is because of the very complicated nature of the disaggregated model and also because of the difficulty in obtaining data.

The input-output table must be made dynamic because of the long term nature of large water resource projects. As has already been mentioned, when long term projections are needed the model must be dynamic because of technological changes and other affects which occur over long periods which will cause the technical coefficients of the input-output table to change.

Since externalities and secondary benefits have a large influence on the economic growth of a region, and depending on the size of the project, on the general economy, it is very important to the decision-maker to have a knowledge of these externalities and secondary benefits when the project is still in the planning stages. Input-output models of the dynamic nature can give such information to the decision maker with, like any other forecasting tool, a margin of error. This margin of error, for the most part, is caused by the forecasting of future demand and the effect the project will have on future demand. The dynamic coefficients will be the cause of some error but the projection of interindustry activity will be more accurate than if static coefficients had been used. But this hypothesis has yet to be substantiated by fact.

Where a dynamic macro tool is needed, as in large scale water resource projects, cost-benefit analysis is not enough. Cost-benefit analysis lacks in the macro nature of input-output tables and deals primarily with direct costs and benefits when analysing a project. Externalities and secondary benefits and costs are considered only insofar as they can be determined by another method of forecasting. The cost-benefit analysis is primarily concerned with the immediate effect of the project on the region. It is more of a micro static tool which is not sufficient for large projects.

The cost-benefit analysis is most effectively used in ranking projects in co-operation with an input-output model. However, since data is very difficult to collect for input-output models, we may be forced to use cost-benefit analysis alone. Also, cost-benefit analysis may be useful in small, local water resource projects where no secondary benefits or externalities of a pecuniary nature are involved.

CHAPTER IV

AGGLOMERATION AND WATER RESOURCE ALLOCATION

Introduction

Economies may be internal to the firm, such as economies of large scale production; external to the firm and internal to the industry, such as backward and forward linkages; or external to the industry, such as urbanization economies. These economies are the basis of agglomeration theory and may become confused very easily but are the source of major benefits accruing to resource projects.

Agglomeration is the attraction of one firm or industry for another. The attraction of industries to an area through agglomeration economies may be caused by the lowering of costs through: (1) economies of scale, (2) backward and forward linkages, (3) localization economies, and (4) urbanization economies.

Economies of scale induce agglomeration through reducing the costs per unit of output as production is agglomerated and expanded. Localization economies are economies gained by an industry locating near the source of inputs, such as raw materials, or near the market. Thus firms using the same input, such as hydro electric power, will be induced to agglomerate near the area where the input is produced. In many cases, by locating near the supplier or the market, a firm saves on transportation costs, therefore inducing agglomeration. Urbanization economies are economies gained by many

firms and industries locating in a general area. In this manner the population is increased and services such as water and highways become cheaper. Urbanization economies in this manner also become inducive factors of agglomeration.

Backward and forward linkages are also an important influence in bringing industries close together. By backward linkage effects we mean the process by which industries attempt to induce the development of suppliers to supply them with domestic inputs. By forward linkage effects we mean the process by which industries induce activities to rise their outputs as inputs. As a result, forward and backward linkages become a factor of agglomeration.

In general, this chapter will examine these agglomerative factors with special reference to water resource projects. Once the factors of agglomeration are examined, there will be an attempt to show the relevance of these factors to water resource projects.

Economies of Scale

Large-scale economies can affect the location of production. Suppose there are two companies supplying the market in a particular area. If both companies had similar cost patterns, then each would supply the closest market (ceteris paribus other factors). Transportation costs would make it unprofitable for one company to enter a territory close to the other company. But now suppose the cost patterns of

each company were not the same in that as one company produces more, costs fall below that of the other company sufficiently to cover increased transportation costs as the company moves into the market of the other company which experienced economies of large scale production. This would be a desirable shift in production since the saving experiences from the increased production is greater than the increased transportation costs.

Secondary effects of economies of large scale production may occur as the company produces on a larger scale. The process of production may become so specialized that production may require the use of highly specialized input, such as hydro electric power. These inputs cannot be fully utilized by one company. If the agglomeration effects of economies of large scale production is great enough, then such specialized inputs may be used by many companies attracted to the area, each of which cannot fully utilize the input alone. Such specialized inputs must then become the basis of independent auxiliary industries supplying the other industries with services. As hydro power plants develop, again economies of large scale production is experienced, resulting in cheaper hydro power. This then attracts more industries, which have hydro electric power as an important input, to the area therefore aiding in the development of the area.

There may even be further agglomeration effects if the need for maintenance of the plants and machinery is

greater as a result of economies of large scale production. In such cases the maintenance department may be expanded to supply extra services. This will also become a factor of agglomeration as the area develops. Work will become more specialized with economies of large scale production in both maintenance and production.

Large-scale production also leads to saving in buying raw materials and other inputs, and marketing because these functions can also be carried on a much larger scale; a further inducement for a plant to expand. "The isolated large-scale plant is more effective than the small one because it can buy and sell on a large scale, thus eliminating the middleman."[1] Further economies can still be developed by the large plant developing its own market for its materials, taking the materials in the necessary quality and quantity when the need arises. Small plants must buy their materials in advance and store them, therefore losing interest on the capital invested and incurring an extra storage cost. Also general overhead costs fall as the plant expands in size and in general as a plant agglomerates all its departments in one area. "Gas, water mains, streets, the whole 'general apparatus will become cheaper for the individual enterprise at the

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[1]C.J. Friedrick, ed., Alfred Weber's Theory of Location of Industries (Chicago: The University of Chicago Press, 1929), p. 130.

high level of technical development and effective utilization made possible through social agglomeration."[1]

Also, in marketing the product, agglomeration permits economies because the concentrated industry produces a sort of large unified market for its products. The whole marketing organization of the industry could possibly be dispensed with because of the development of visits and direct buying at the place of production which could replace travelling salesmen.

Economies of large scale production is a factor of agglomeration, i.e. induces agglomeration and agglomeration induces economies of large scale production and marketing. They both work to induce the other and together improve general economic efficiency.

Localization Economies

A. Agglomeration and Transportation Orientation. Localization economies is a more controversial topic in agglomeration theory than economies of scale. The controversy actually lies within the influence localization economies has on agglomeration economies. Weber raised the question as to what influence localization economies has on agglomeration and he provided precise answers.

> The center of agglomeration must obviously lie within the common segments of the critical isodapanes, for

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[1] *Ibid.*, p. 131.

> within these common segments lie the points at which production may be concentrated without prohibitive deviation costs. . . . But where will the center of agglomeration actually be located? It will be located at that one of the several possible points of agglomeration which has the lowest transportation costs in relation to the total agglomeration output.[1]

> In this connection the critical isodapane for any unit of production is that locus of points for each of which transport costs in assembling the raw materials and shipping the finished product exceed the corresponding transport costs associated with the optimal transport point by a constant amount. This amount is equal to the economies of agglomeration that would be realized by association with the assumed unit of agglomeration.[2]

In other words, the center of agglomeration will be the point where transportation costs are at a minimum. For example, it is cheaper to transport small inputs to a point of production than it is to transport large inputs to the place of production. Therefore "the large units of production will attract the smaller units to locations near the former's original minimum points, and will there fix the center of agglomerations."[3]

When there exists more than one possible location in which agglomeration may occur, agglomeration will still occur

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[1] Ibid., p. 138.

[2] Walter Isard, Location and Space-Economy (Cambridge: The Massachusetts Institute of Technology, 1956), p. 176.

[3] C.J. Friedrich, Alfred Weber's Theory of Location of Industries, p. 138.

at the location which yields minimum transportation costs.

> The isolated units of production will not agglomerate arbitrarily or indifferently with any of the others near them; but rather they will agglomerate with those smallest units which just suffice to make up a requisite unit of agglomeration, and which they can attract farthest to themselves, attracting first the smaller ones and then going upward in the scale to the larger ones.[1]

Labor locations also have a significant influence on agglomeration. Production tends to center around locations where cheap labor is available as well as agglomeration economies. If materials used in production as well as the market for the products are located with the labor, this will strengthen the center of agglomeration. But while labor will continue to be a factor of agglomeration, the materials used as inputs in production will eventually be eliminated. In agglomeration, the geographical position of the attracting place of agglomeration is affected, since its position itself depends in part upon the exhausted materials. This may change the whole basis of agglomeration. Now a new position may be selected as the center of agglomeration, but the separation from the old basis is not complete; the old deposits still continue to effect the process of agglomeration.

Now then, according to Weber, the only factors which need to be considered as the basis of a new location for the center of agglomeration are; "(1) the centers of consumption

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[1] _Ibid_., p. 140.

which are to be served from this point of agglomeration and (2) the sources of materials which remain in use."[1]

This is where one finds Weber's analysis a bit unrealistic. If a firm is already well-established in the area, with permanent structures, then it becomes very unlikely that the firm will move. It would seem logical that the firm will transport inputs to the original structures. For new firms not yet situated Weber's analysis is realistic but has limited application, especially in understanding the forces which determine the site at which agglomeration will take place.

> Imagine an entrepreneur who controls three units of production and who confronts the location problem. . . . Considering the locational polygon of raw material sources and markets relevant for each unit and assuming that economies of scale are not operative, he could locate each unit at its optimal transport point. Or, he could locate the three units adjacent to each other at a center of agglomeration thereby achieving localization economies but only by incurring larger transportation costs. This is one type of situation to which Weber's scheme has most application. In this type of situation, each unit of production may be visualized as substituting transport outlays for production outlays of one sort or another when it shifts to the center of agglomeration.[2]

But due to the transportation rate structure, buyers and sellers will be brought together therefore achieving both savings in transportation and localization economies.

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[1]*Ibid.*, p. 142.

[2]Walter Isard, *Location and Space-Economy*, p. 179.

> Because of terminal costs and the high costs associated with loading and unloading, transportation rates usually begin with a high initial charge. . . . In order to avoid paying the high initial cost twice, once on inputs and again on outputs, it is profitable for a firm with one market and one source of supply to locate either at the market or at the source of supply. Ordinarily the transportation rate structure discourages intermediate locations.[1]

This transportation rate structure therefore has a very noticeable effect on the center of agglomeration and Weber's analysis is very relevant.

Now another problem presents itself, this is; where will the firm locate, at the market or at the source of supply? Here again transportation rates are influential since the transportation costs are determined by the weight of the goods being transported. As Weber has pointed out, if the inputs are heavy and bulky, then the firm will locate near the source of supply while if the finished product is more costly to transport, then the firm will locate near the market. Also very often freight rates discriminate against finished goods since the demand for transporting these goods is relatively inelastic. This will induce the firm to locate near the market causing the market forces to be a factor of agglomeration.

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[1]C.E. Richter, The Impact of Industrial Linkages on Geographic Association (unpublished Ph.D. dissertation, University of Illinois, 1968), p. 4.

B. Agglomeration and Labor Orientation. What is the result if the forces of agglomeration are considered for industries oriented at the labor locations?

> When agglomerative forces appear in an industry oriented toward labor, there takes place a competition between the agglomerative deviation and the labor deviation, a struggle to create 'locations of agglomeration' as compared with 'labor locations,' both being upon the foundations of the transportation groundwork. That one of the two forces which can offer the greater net economies over and above the transportation orientation will be the victor.[1]

We cannot compare the net economies of locations of agglomeration with labor locations to discover which will be chosen by the firm because labor locations may be a point of agglomeration. The economies of agglomeration will be separate and distinct from the economies of labor which attract industry toward a particular labor location.

> These economies must therefore be added to the economies of labor if we wish to know the total amount of economies with which the labor locations compete with the purely transportational locations of agglomeration. The question then is, which is larger, the economies of agglomeration, or the economies of labor plus the economies of accidental agglomeration at the labor locations?[2]

From this analysis, firms who obtain economies from accidental

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[1]C.J. Friedrich, Alfred Weber's Theory of Location of Industries, p. 157.

[2]Ibid., p. 157. Accidental agglomeration is a labor location which is itself a point of agglomeration. Pure agglomeration is a transportation location without other economies.

agglomeration and from labor locations which are as great as or greater than the economies from pure and independent agglomeration, which has as a basis transportation costs, will retain their labor orientation.

But the selection of labor locations can lead to factors of agglomeration within such locations.

> First, industries with a highly developed labor orientation have a selection of labor locations due to the competition of such locations with one another. This very process of selection causes a considerable accidental agglomeration at the more favorable labor locations; labor orientation itself shows a tendency to agglomerate. Second, the strength of this tendency to agglomerate depends upon three of the four factors upon which the strength of the independent tendency toward agglomeration depends. Locational weight, rates of transportation, and density of population affect labor orientation and its accompanying accidental agglomeration in the same way and just as much as they affect the competing independent or pure agglomeration.[1]

The addition of economies of agglomeration to labor economies will strengthen labor orientation. For wherever the accidental agglomerations caused by the labor locations are larger than any possible independent agglomerations within the groundwork of transport orientation, the balance between the two is added to the economies of the labor location and this strengthens the power of attraction of the labor location. Due to the additional economies of accidental

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[1] _Ibid_., p. 158.

agglomeration, labor orientation as a whole will prevail over transport orientation where it would not otherwise prevail. Also within the labor orientation of the industries the strong labor locations, because of cost reductions, get a further advantage because the amount of production attracted to the location is itself a factor of agglomeration. This will attract production from weaker locations further strengthening the labor location. "The essential effect which the tendencies to agglomeration will have on labor orientation is to increase its inherent tendencies toward concentration at a few locations."[1]

Urbanization Economies

Urbanization economies are much like localization economies.

> In the study of urbanization economies we face . . .:
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> (1) economies which stem from a higher level use of the general apparatus of an urban structure. . .; and (2) diseconomies engendered by rises in the cost of living and money wages, in the costs of local materials produced under conditions of diminishing returns, in time-costs and other costs of transportation, and in land values and rents."[2]

Here, in the study of urbanization economies, Weber's analysis is not very useful since cities evolve over time.

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[1] *Ibid.*, p. 162.

[2] Isard, *Location and Space-Economy*, p. 183.

Cities are much less subject to relocation. Their investments are fixed in conjunction with their social institutions causing geographic immobilities and rigidities. Cities therefore attract or repel units of production in accordance with the economies and diseconomies contained within the city; that is, "units are attracted to or repelled from cities according to a simple comparison of advantages and disadvantages generated by these cities."[1]

Some of the advantages and disadvantages vary as the cities grow or become smaller. Marketing of products will become less costly as the cities grow in size, but the delivery of the products may become more expensive due to traffic conditions. In considering locations in urban centres all these economies and diseconomies are considered in the decision making process. But the economies and diseconomies cannot be aggregated all that easily. The economies and diseconomies are interdependent, making matters much more complicated. Nevertheless, urbanization economies is an important factor of agglomeration which deserves careful attention.

Qualities of the Industry and Agglomeration

This section will deal with the question, "upon what qualities of a particular industry does the amount of its agglomeration depend. . . ? This question causes us to

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[1] *Ibid.*, p. 183.

examine more carefully those conditions of agglomeration which depend upon the nature of the particular industry."[1] There are two such conditions of agglomeration: (1) the locational weight or the importance of location to industries and (2) the function of the economy. The importance of location to industries is simple and only needs mentioning. An example of an industry or firm which places high values on location is a mining industry which must be located with the sources of the mineral.

But the "function of the economy" is not as clearcut. This condition is more of an intangible characteristic of an industry. For this reason we cannot know by deduction what characteristic of industry the function of the economy will depend on or how it depends on that characteristic. But by observation there are certain types of industries which possibly have "large units of agglomeration with resultant high percentages of compressible costs--an effective function of economy."[2] These are industries whose products obtain values through the manufacturing process.

> The reason why only industries with such a high value added through manufacture will have an effective function of economy is simple. . . . Only where high labor costs per ton of product exist can considerable labor

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[1]Friedrick, Alfred Weber's Theory of Location of Industries, p. 162.

[2]Ibid., p. 163.

> economies per ton of product be effected; and the same consideration holds good for manufacturing costs in general; including the costs of machinery, etc."[1]

These costs appear in the value of the product. If these types of costs are high, they can show high functions of economy by compressing costs through agglomeration. This reduction in costs through manufacturing yields a yardstick for measuring the effective tendency toward agglomeration of industries. But this does not tell us everything about the trend towards agglomeration of a particular industry, and it does not tell us its actual function of economy. If the value added is through labor, then the factor of agglomeration is labor. If the value added is through machines, then the factor of agglomeration is mainly through materials since labor is a minor input. Now this can also be used as a yardstick in determining the tendency toward agglomeration attributable to a characteristic of the industry. "Now we can formulate: industries with a high coefficient of manufacture show strong tendencies to agglomerate; industries with low coefficient of manufacture show weak tendencies to agglomerate; and these tendencies are inherent in their nature."[2]

Now in what forms will this agglomeration be found in reality? Agglomeration influences both labor-oriented

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[1] Ibid., pp. 163-164.

[2] Ibid., p. 166.

industries and transport-oriented industries. The influence of labor oriented industries is through the contraction of labor locations. Only industries with very weak labor orientation will be influenced by transport orientation without showing labor orientation. Technical agglomeration is only found in industries with a high coefficient of manufacture which is composed of value added through labor and machines. Values added through machines is connected with consumption of materials, and this cannot cause the coefficient to be high because of the resulting high locational weight. "Consequently industries with a high coefficient of labor will show the strongest tendencies of agglomeration."[1] Technical agglomeration will have the consequence of strengthening labor agglomeration.

The results of this then is to find transport-oriented industries concentrated not very far away from their points of smallest costs of transportation. When we find an industry deviating from its transport orientation, then we may assume it is labor-oriented because technical agglomeration is not a very strong force. This, then, separates industries into two groups: transport-oriented and labor-oriented industries.

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[1] Ibid., p. 167. The coefficient of manufacture is the ratio of production costs less the cost of labor to total production costs.

How does this agglomeration affect development in actual life? The three conditions of agglomeration are: density of population, transportation rates, and the coefficient of manufacture. The first two conditions continuously increase agglomeration. Declining transportation costs increase the size of the area of agglomeration. Increases in the density of population increases the quantity of production through an increased demand for the product and an increased supply of labor and therefore the units of agglomeration. But how do the changes of character in industry aid in development? This character of an industry is what was referred to as the coefficient of manufacture which leads to agglomeration but only if the character of the industry is important in that it causes the industry to be connected with other industries.

As can be seen in the eighteenth and nineteenth centuries, the value added through manufacture became the cause of considerable agglomeration. Industrial production increased in size, which meant higher units of agglomeration and more extensive reductions in costs making the higher units of agglomeration more effective. Industries became more developed and organized which was necessary to enable them to utilize the higher units of agglomeration. This change in the character of the industries did have a very large agglomerative effect.

But at the same time this changing of character of

industries created forces working against agglomeration. Machines replaced labor in many cases which means the value added through labor changed to value added through machines. This had the effect of reducing the coefficient of manufacture because value added through machines has smaller agglomeration effects.

Forward and Backward Linkages and Localization Economies

Forward and backward linkages may also induce agglomeration and aid in the development of the area. For example if hydro power is an important input in a firm, the firm will endeavor to locate where there will be a supply of hydro power. If the firm is already established, but the inputs required are not close, then the firm will attempt to induce firms to enter the area to supply the inputs. This is what is referred to as a backward linkage. The forward linkage also has agglomerative effects in much the same manner. For example if a firm is producing a product which does not cater exclusively to final demand, it will induce other firms to utilize its outputs as inputs.

Therefore development policy must attempt to utilize these backward and forward effects. These effects are very vital sections of agglomeration effects but they can only be utilized if there is some knowledge as to how different economic activities can be induced by backward and forward linkages. But first we must have some knowledge of the linkage concept itself.

A. <u>The Backward Linkage</u>. Suppose an industry is established. What is the probability that other industries will be established through the linkage effects? Determining the probability is a very important factor in determing the agglomeration effects.

> The probabilities can be interpreted as measuring the strength of the stimulus that is set up. For backward linkage, this strength can be roughly measured as follows: suppose industry W requires annual inputs of $Y_1, Y_2, \ldots Y_N$ and suppose that the minimum economic size (in terms of annual productive capacity) of firms that would turn out these inputs is equal to $a_1, a_2 \ldots a_N$; then the strength of the stimulus or the probability that the setting up of industry W will lead to the setting of industries producing the inputs is equal to the ratio of the Y's to the A's.[1]

In underdeveloped countries where backward linkages are needed, they are virtually non-existent. This is because of the very weak linkage effects connected with primary production. This can be seen by examining the interdependence of industries, in an input-output table. In the underdeveloped countries this interdependence is very small. But the backward linkage is working through inputs in these situations. These countries are importing the semi-finished products and build firms to process the semi-finished product for final demand. Eventually as this grows, it has a backward linkage

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[1]Albert Hirschman, <u>The Strategy of Economic Development</u> (New Haven: Yale University Press, 1959), p. 101. The largest value the ratio can take on is unity, i.e. if y's are equal to or larger than the a's, the value of the ratio is unity.

effect. When demand for the semi-finished products grow so that its demand will support a firm processing the raw material into the semi-finished product, this will induce the building of the firm and so on, until the demand for raw materials is large enough to induce the country to exploit its own natural resources. Firms will be induced to locate close together because of their dependence, developing the region.

B. The Forward Linkage. The assessment of the probabilities in creating the agglomerative effects due to forward linkages is not as straightforward. The concept of economic size does not play an important role since the market for industries brought into being by a forward linkage does not depend on suppliers. The strength of the forward linkage and the probabilities of industries being established through a forward linkage will then depend on the importance of the input to the forward linked industries in their final product.

> If these inputs are a very small fraction of the industry's eventual output, then their domestic availability is not likely to be an important factor in calling forth that industry. If, on the other hand, these articles are subjected to few further manufacturing operations then the strength of the forward stimulus is likely to be substantial, provided demand is sufficient to justify domestic production.[1]

Where the inputs are of minor importance in the final

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[1] Ibid., p. 102.

product, the firm producing the input is usually established as a satellite industry and these satellite industries may be established through backward or forward linkages.

> A satellite industry will usually have the following characteristics:
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> (a) it enjoys a strong locational advantage for proximity to the master industry;
> (b) it uses as principal input an output or by-product of the master industry without subjecting it to elaborate transformation, or its principal output is a--usually minor--input of the master industry; and
> (c) its minimum economy size is smaller than that of the master industry.[1]

Once a master industry is established, satellite industries are almost certain. But the establishment of the industry also produces a stimuli towards the setting up of non-satellite industries. But this stimuli is much weaker for non-satellite industries. This weakness may be explained by three factors which define satellites.

> Linkage is reduced to the fact that an input of the newly established industry is an output of the to-be-created industry or vice versa, but the established industry would not be the principal customer or supplier of the to-be-created industry; in fact, particularly in cases of backward linkage, minimum economic size of the to-be-created industry would frequently be larger than that of the industry where the linkage originates.[2]

But there must be a cutoff point where the stimulus

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[1] Ibid., p. 102.

[2] Ibid., p. 103.

resulting from an industry is not significant even for the creation of satellite industries. This may be the case for instance in an industry established which needs paper for its labels. This creates a demand for paper but the stimulus is not enough to bring about the development of pulp and paper plants.

C. Emperical Studies with Backward and Forward Linkages.

Charles Richter evaluated the impact of industrial linkages on the location of manufacturing activities in his dissertation published in 1968. In this dissertation he examined six hypotheses pertaining to the importance of linkages and agglomerations of manufacturing activities. These hypotheses are as follows:

> The first hypothesis is that demand linkages and supply linkages are equally important locational influences on all of the manufacturing sectors considered together. . . . The second hypothesis states that the earlier stages of manufacturing are generally supply oriented. . . . The third hypothesis is that strongly linked industries are more likely to be located close together than weakly linked industries. The fourth hypothesis has two parts, both of which pertain to industrial sales to the final demand sector. . . . The first part of the hypothesis is that there are more industrial linkages accompanied by geographic associations, on the average, among industries which do not sell large proportions of their output to the final demand sector, than among industries which sell larger proportions of their output to the final demand sector. The second part is that industrial linkages are equally likely to be complemented by geographic associations, regardless of industrial sales to final demand. . . . Fifth, a hypothesis is examined which states that industrial linkages are equally likely to be accompanied by geographic associations irrespective of the processing stage at which industries operate. . . . The sixth and last hypothesis is that the

> dispersion of employment proportions for industries which do not sell large proportions of their output to final demand equals the dispersion 'of the employment proportions for industries which sell larger proportions of their output to final demand.'[1]

After examining the data and analysis, Richter concluded that industrial linkages do lead to agglomerative forces. He found that linkages exert strong locational forces on manufacturers to locate near their sources of material or near the market. Because of backward and forward linkages he found there was a tendency for "industries to cluster together within the 57 of the nation's largest metropolitan areas. Since linkages apparently encourage industries to concentrate in these areas, . . . industrial linkages probably induce manufacturing industries to agglomerate."[2]

In examining his six hypothesis, his results were found to be significant. Supply and demand linkages were found equally important in creating agglomerative forces. Supply linkages were found to be more important locational influences on primary manufacturers while demand linkages were more important to later stage manufacturers. Also strong linkages were found to be more powerful locational forces than weaker ones. Regardless of the size of final sales, the likelihood of sectors being attracted to other locations

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[1]Richter, The Impact of Industrial Linkages, pp. 5-8.

[2]Ibid., p. 86. The nation referred to is the United States of America.

because of linkages with other industries being equal. But because there are more interindustry linkages between sectors closely linked to final demand, these manufacturers average more locational associations than manufacturers who sell largely to the final demand sector. Because resource users are more material oriented than market oriented, linkages are not likely to occur between resources users and the market. Those secotrs "have wider dispersions of their employment proportions inside the 57 metropolitan areas because they are not so sensitive to the sources of final demand as sectors which sell larger amounts of their output to the final demand sector."[1] The examination of these hypotheses brings to light some ways in which industrial linkages encourage industries to agglomerate and shows that industrial linkages are important locational and agglomerative factors.

Now the question arises as to how corporate linkages are made or are derived from an input-output table. From the input-output table the degree of interdependence shown by any one industry can be measured by computing:

> 1. The proportion of its total output that does not go to final demand but rather to other industries, and
> 2. the proportion of its output that represents purchases from other industries.[2]

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[1] Ibid., p. 87.

[2] Hirschman, The Strategy of Economic Development, p. 105.

This measure can be taken to represent forward and bakcward linkage effects. Chenery and Watanabe, in a recent study of the degree of interdependence of various industries in Italy, Japan and the United States, computed the averages and the resulting figures representing the degree of interdependence "can be taken as a general indication of the ranking of these industries from the point of view of backward and forward linkage effects."[1] Since more importance is placed on backward linkages than on forward linkages, industries with high backward and low forward linkages are ranked before industries with high forward and low backward linkages. This method of determining linkage effects is very rough but nevertheless will yield an approximate idea of the direct and indirect effects of projects on the economy or region.

D. Backward and Forward Linkage Considered Together

As has already been mentioned backward linkages are much stronger and more effective than forward linkages. It would be absurd to assume industries would be created or a certain investment would take place when domestic demand reaches a certain level. Also forward linkage effects never occur in pure form, they are always accompanied by backward linkage which results from the pressure of demand. But because of these reasons, the forward linkage is an important

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[1] *Ibid.*, p. 105.

reinforcement to the backward linkage. Investments as a result of both backward and forward linkage are therefore a much safer investment and easier to justify. As an example industry A may be established because of the final demand for the product. Once industry A is developed, its output may possibly be used as an input of another industry. Industry B will develop to supply a product to the final demand sector and also use the output of industry A. This will cause the sales of industry A to increase. This will cause the industry to expand because now it must not only satisfy final demand but also industrial demand. "In other words, while the existence of industry A helps to induce the establishment of industry B, this establishment in turn induces the building of new capacity for A."[1]

But very often there is a strong resistance against backward linkages especially in developing countries. These countries begin their development process by putting the finishing touches on imports. Once demand for imports is large enough to economically support the industry, there will develop a backward linkage inducing domestic investment in this industry to produce the imported materials. But the manufacturer who is producing the finished products will resist the development of domestic industries producing the finished products for several reasons. First he fears the

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[1] *Ibid.*, p. 117.

domestic production will not be as good and uniform quality as the imports. Secondly, he may become independent on a single producer when previously he could shop around the world. Thirdly, domestic competition in his product may become more active. Finally, his location may be wrong once domestic production begins and his supply of materials is changed.

Therefore, starting the development of an industry, beginning with the last stages first, may be a disadvantage. Not only will backward linkages not be effective, but backward and forward linkages together may not be effective.

Agglomeration, Backward and Forward Linkages and Water Resource Projects

Water resource projects are very often the result of either backward or forward linkages and very often the cause of agglomeration effects. In the last half century, with hydro power becoming a much more important input in many industries, hydro power plant development has been encouraged. The development of hydro plants with equipment and services may mean the use of hydro power as an input.

Irrigation projects also have some agglomerative effects. Many times irrigation projects arise because of the need for irrigation and irrigation projects induce industries and induce expansion in the production and processing of agricultural products.

Barren lands have been developed through irrigation projects. The development of barren lands induces industries to locate in the area to supply services to the farms and people in the area.

Agglomerative and linkage effects are therefore significant in evaluating water resource projects. To evaluate agglomerative and linkage effects it must be known how they operate and what are the causes of these linkages and agglomerative effects. Once this knowledge is gained the input-output model may be utilized to determine the importance of these effects by observing interindustry transactions. Through an analysis of this nature one can obtain a much closer insight into the effects water resource projects have on the region and the economy. But one must first understand the theory of agglomeration before this secondary benefit can be incorporated into an input-output analysis.

CHAPTER V

CONCLUSION AND SUMMARY

The major purpose of this thesis is to evaluate the usefulness of cost-benefit analysis as a method of allocating Canada's natural resources, and propose alternative methods.

Cost-benefit analysis is suitable when the projects to be compared are of a similar nature, and when effects are of a micro nature with minor pecuniary externalities and secondary benefits. But when large scale projects are being assessed, a cost-benefit analysis is far from satisfactory. Pecuniary externalities and secondary benefits, both of which cannot be rigorously dealt with in cost-benefit analysis, become more important when the effect of the project on the economic growth of the area is being considered. Large scale projects are of a macro-dynamic nature which cost-benefit analysis is not conceptually designed to deal with since it is primarily a micro-static tool.

In evaluating short run cyclical effects of water resource projects, using the proposed tools, one must first assess the increased demand by industry. To estimate the short run effects, the matrices of static input-output tables

are then inverted enabling an estimate of increased inter-industry activity. To estimate long run secular or growth effects, the locational pull of the project must be assessed by examining the attractions such as transportation economies, low cost inputs such as hydro power and other natural resources. Matrices of dynamic tables are then inverted to estimate the increased interindustry demand due to the industries located in the area because of the project. This estimates the secondary benefits, but to account for pecuniary externalities the technical coefficients must be made to reflect price changes.

Growth effects must then be measured. The increase in population must be calculated and the increase in the number of families must be estimated. Then changes in per family income is calculated and used as a measure of economic growth.

The project chosen will then be the one which optimizes the increase in economic growth. Optimization of economic growth will be attained when per family income is maximized since this is the measure of economic growth used.

With special reference to water resource projects, the macro-dynamic nature of the project may come about in a number of ways. The development of hydro electric power could possibly be macro in nature with many pecuniary

externalities and secondary benefits which would be overlooked by a cost-benefit analysis. A large scale hydro power project could cause industries in which hydro power is an important input to be attracted to the area with their service industries and services in general for the increased industry and labor force attracted to the region. The needs of both the new industry attracted to the area and the hydro power plant may cause the production in the rest of the economy to expand resulting in widespread decreases in unemployment. Therefore secondary benefits and externalities should be considered in developing such projects because of the stimulus to economic growth in the region, and in general the stimulus to economic growth in the entire economy.

Large scale irrigation and transportation projects may have similar effects on the economy. For example with large scale irrigation projects which induce increased agricultural activities, agricultural suppliers and services are attracted to the area increasing there per family income, employment and activities in this field. These secondary benefits and pecuniary externalities which affect the economic growth of the region are again not considered in a cost-benefit analysis, and as a result the project may not materialize; or if pecuniary externalities cause a reduction in the benefits of the project, again not being considered by cost-benefit analysis, this may cause the project to

materialize when, in actuality, another project should have been chosen. The development of the St. Lawrence Seaway is a prime example of the macro-dynamic effects which the large scale development of Canada's water resources may produce.[1] The development and utilization of this seaway for transportation purposes has been considered to be an important factor in the growth of the national economy. It appears clear from these examples that pecuniary externalities and secondary benefits resulting from such large scale projects cannot be dealt with as in a cost-benefit analysis, but should be considered as important components in any analysis when the choice of projects and the decision to develop a resource is being made.

Now the problem of predicting such pecuniary externalities and secondary benefits presents itself. In attacking the problem of pecuniary externalities and secondary benefits, this thesis has suggested the conceptual and empirical usefulness of input-output analysis. For short term projects, a static input-output table was found to be sufficient, but for long term macro-dynamic projects the input-output model must be made dynamic. By using present best practice industries and deriving their technical coefficients, assuming

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[1]Macro-dynamic effects are large scale effects which affect the economic growth of the larger part of the economy and change over time.

the average industry in the future will have technical coefficients similar to the most efficient industries at present, the input-output model may be made dynamic. Pecuniary externalities and secondary benefits and their effects on the economic growth of Canada could then be predicted with some degree of accuracy.

Consideration has been given to the difficulties of making an input-output model dynamic. Identifying best practice industries may indeed be difficult, so that other methods of making the input-output model dynamic must be investigated. The input-output model could possibly be made dynamic by changing coefficients by a constant percentage or by incorporating relative price changes into the derivation of the technical coefficients. Nevertheless the static input-output model which has been heavily utilized for predictive purposes by such analysts as Isard and Chenery has proven quite successful and does provide an approximate estimate of pecuniary externalities and secondary benefits.

Water resource projects of a large scale nature also have agglomerative effects. For example hydro electric power developments may attract industries to the area because of economies of scale, backward or forward linkages, urbanization economies or localization economies, all induced by the development of the hydro power plant. These industries which are attracted to the area will themselves attract service

industries and other industries to the area which are dependent on them. But to predict which industries will be attracted to the area one must investigate the linkages between industries. By using input-output tables an estimate of the linkage can be arrived at by observing interindustry transactions and estimating the dependence between industries.

It is conceded that cost-benefit analysis is satisfactory when dynamic conditions are not present. When projects have dynamic effects on the economy, then other methods of analysis must be utilized. For projects of a static nature, either macro or micro, cost-benefit analysis is a satisfactory tool of analysis.

By more rigorious utilization of agglomeration theory in conjunction with dynamic input-output models, Canada can more accurately predict the effects on the economy of large scale developments of the natural resources. Since Canada is so richly endowed with natural resources currently under consideration for development or export, more concern with the allocation of these resources may be in order. More efficient and accurate tools for allocating resources should be a constant concern to Canada and continued research in this area should be stressed since natural resources may be an important component in Canada's future growth performance.

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